Night Vision Image Enhancement Based on Double-Plateaus Histogram

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Abstract. Night vision image has characteristics of low contrast, weak-arrangement gray and dim vision. Double-plateaus histogram enhancement algorithm is presented to enhance them. By setting a higher threshold value, the algorithm can constrain the background and noises. At the same time, the algorithm can magnify dim targets and image details by setting a lower threshold value. With the proposed algorithm, disadvantages of classical histogram and other plateaus histogram enhancement algorithm are overcome while achieving high contrast. Experiments prove that the proposed algorithm can enhance image contrast effectively and preserve image details simultaneously. Moreover, it can also overcome over-bright phenomenon.

Keywords: Double-plateaus histogram, Image enhancement, Night vision low-light-level image.

1 Introduction

Night vision low-light-level image [1,2] equipments play an important role for military and civilian application, and the key kernel is the low-light-level image processing system. The interval and density of gray contrast are very low and gray value range is great narrow, so night vision image's vision is dim and gray contrast between target and background is extremely small. Therefore, it is very important to enhance image and improve its vision quality. The enhancement method is an availably and practical method which can improve image vision quality and distinguish target from complex low-light-level image.

Histogram equalization [3] is a traditional technology to enhance image contrast, but it is difficult to control the enhancement result in practice and all image histogram is equally equalized. For the area with low-gray-frequency, contrast will be weakened or eliminated moreover. That is to say noise may be magnified. Thus, if histogram equalization is directly used to enhance night vision low-light-level image, the background gray levels and noise will be strengthened. On the contrary, target gray levels will be lacked. It may enhance background and noise and reduce the target and details contrast. Sometimes the over-bright phenomenon [3] may come out. So traditional histogram equalization algorithm is not suitable for night vision image. In order to

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G. Shen and X. Huang (Eds.): ECWAC 2011, Part I, CCIS 143, pp. 74–79, 2011.

overcome the problem, many scholars put forward different methods [4-6]. These methods can enhance image and get more chance to obtain the details. But it is very difficult to get the suitable threshold and has complex account and many gray levels are still united together. Target and details are lost. The image becomes dim more. The fixed threshold can't be self-adaptive to the image. Therefore, a self-adaptive double-plateaus histogram enhancement algorithm is proposed. By self-adaptive setting double-plateaus threshold, it can adjust the plateaus threshold value to different images. Since the algorithm united both the merits of above algorithms. It can constrain background and noise efficiently and at the same time magnify the small target and details. Moreover, it can also avoid the image to become dim more and overcome over-bright phenomenon.

2 Double-Plateaus Histogram Enhancement Algorithm Design and Analysis

Histogram equalization is a certain transform on original image that changes histogram's distribution more equal and enhances image. Plateau histogram equalization [7-9] which modifies original histogram is a special form of histogram equalization. Histogram equalization gets accumulated histogram from statistics histogram, but plateau histogram equalization gets accumulated histogram from plateau histogram, then distributes the image gray to get the equalized histogram by accumulated histogram to obtain equalized image.

In practice, selecting plateau threshold has a very important influence to the enhancement result. If threshold value is not suitable, it may even impair image vision quality. It can overcome the disadvantages of traditional histogram equalization and constrain the background and noise. The algorithm has the features of small calculation, excellent image enhancement and real-time performance, but it still has the problem that will merge the gray level and lose some details. Hereupon, self-adaptive double-plateaus histogram enhancement algorithm for night vision low-light-level image is proposed. Double-plateaus threshold values can be self-adaptively adjusted to different kinds of images. The upper-plateau threshold constrains the background and noise, the lower-plateau threshold magnifies the small target and details. It can overcome the disadvantages of traditional histogram equalization. The proposed algorithm can synthesize the advantages of upper-limit and lower-limit plateau algorithm, so it can enhance the image and remain the detail.

The image histogram is modified through self-adaptive setting two suitable plateau-thresholds A and T with Equation (1).

$$P_T(k) = \begin{cases} 0 & P(k) \le 0.2A \\ A & 0.2A < P(k) \le A \\ P(k) & A < P(k) \le T \\ T & P(k) > T \end{cases} \tag{1}$$

In the Equation (1) $P_T(k)$ is the plateau histogram, $P(k)$ is the image histogram, T and A are the upper-limit and lower-limit plateau thresholds, k is the gray level, $0 \le k \le 255$.

The upper-limit and lower-limit plateau thresholds A and T can be self-adaptively set below.

(1) Get image histogram $P(k), 0 \le k \le M$, one-dimensional 3-neighbour median filter is processed on $P(k)$; selecting the unit which isn't zero in the histogram to constitute an aggregate $\{F(l) \mid 0 \le F(l) \le L\}$, L is the number of the no-zero units;

(2) Find out local maximum value and entire maximum value of all image, then make first-order difference calculation with no-zero units: $F^{(1)}(m)=F(m)-F(m-1)$. $1 \le m \le L$.Find $F(l_i)$ which can accord with such condition of $F^{(1)}(m-1)>0$, $F^{(1)}(m) \ge 0$, $F^{(1)}(m+1)<0$ in $F(l)$. It means that the symbol $F^{(1)}(m)$ changes at this area m(from positive turning to negative value) and $F(l_i)$ is the local maximum value. Where $0 \le l_i \le L, 0 \le i \le N$, N is the number of local maximum values. Then the entire maximum value $F(l_k)$ can be obtained from $F(l_i)$;

(3) Get the average value $F(l_g)$ of the subaggregate $\{F(l_i) \mid k \le i \le N\}$, $F(l_g)$ is the utter plateau threshold value.(4) suppose the image size is $m \times n$, Get the lower threshold A which is the average value of image histogram, that is $A = \dfrac{m \times n}{256}$.

After calculating double-plateaus threshold values and equalizing the histogram, final equalization histogram can be gained by distributing the image gray through using modified cumulative histogram. That are $F_T(k) = \sum_{i=1}^{k} P_T(i) \quad (0 \le k \le 255)$ and $D_T(k) = [\dfrac{255 F_T(k)}{F_T(255)}] \; (0 \le D_T(k) \le 255)$. Where $F_T(k)$ is the cumulative histogram and $D_T(k)$ is the double-plateaus equalized gray value of the pixel whose gray value is k in original image. [ ]means to return the value of a number rounded downwards to the nearest integer. That is round-calculate.

3 Experiments and Analysis

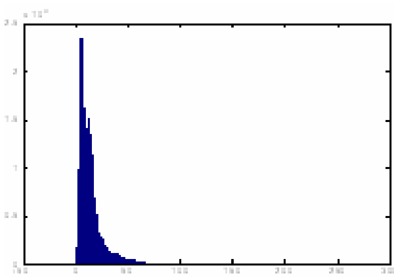
Night vision low-light-level street image is used as an original experiment image. Fig.1 are the images processed by different algorithm and their corresponding histograms. As it's shown in Fig.1 (a)(b)(c)(d), the background, which possesses most image parts is enhanced and the corresponding gray intervals are turned wider. On the contrary target and the details, which possesses the few parts of all image are constrained. Most gray levels of these corresponding parts are united and some parts of details and target are lost. As it's shown in Fig.1(e)(f), though plateau histogram enhancement algorithm gains better effect than histogram equalization algorithm, there still unites some gray levels and losses some details. Fig.1(g)(h) shows the double-plateaus threshold algorithm constrains the background and preserves the details more effectively and also overcomes over-bright phenomenon very well. So the proposed algorithm in this paper has more advantages than the traditional histogram and plateau equalization algorithm. It can get the best image vision.

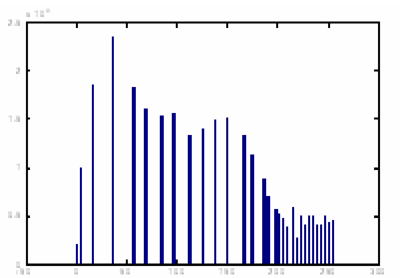

(a) original image

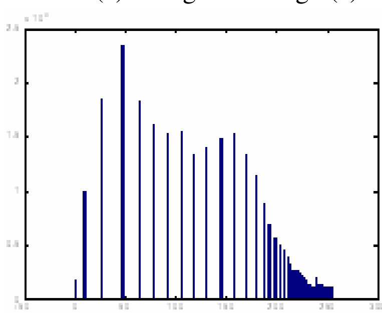

(b)histogram equalized image


(c)plateau histogram equalized image


(d)image enhanced by proposed algorithm


(e) histogram of Fig.1(a)


(f) histogram of f ig.1(b)


(g) histogram of Fig.1(c)

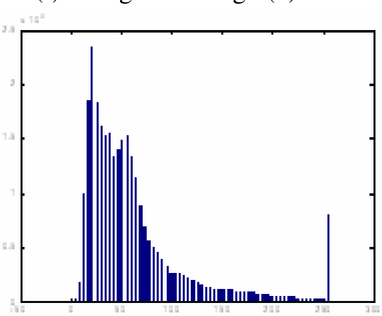

(h) histogram of Fig.1(d)

Fig. 1. Image processed by different algorithm and their corresponding histogram

Besides subjective appraisement, image quality can also be appraised by quantity parameter "fuzzy exponent"[10]. The smaller fuzzy exponent value the more definition of image. Table 1 shows the fuzzy exponent values of each algorithm. Because the proposed algorithm in this paper has the minimum fuzzy exponent value, it can obtain clearer image than other algorithm.

Table 1. Image Fuzzy Exponent of Each Algorithm

Algorithm	Histogram equalization	Plateau histogram equalization	Reference [8] upper plateau histogram	Reference [9] lower plateau histogram	proposed algorithm in this paper
Fuzzy-exponent FB	0.1976	0.2110	0.1191	0.0788	0.0768

4 Conclusion

The traditional histogram equalization is a fast and effective method to enhance the image. While processed on night vision images, it would magnify the background and the noise. Moreover, some small target is difficult to distinguish and over-bright phenomenon would come out. The plateau histogram equalization algorithm can constrain the background and noise, but it still has the problem of uniting gray level and losing the detail. The self-adaptive enhancement algorithm based on double-plateaus histogram can enhance the entire target contrast and preserve the detail. It can self-adaptively select dynamic threshold to different image and has more advantages than traditional algorithm and it can effectively use to enhance night vision low-light-level image in practical.

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